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Novel Device For Aerobic Biodegradability Testing



Incubator

More and more resources are being invested by industry in the field of biodegradable packaging. But just how biodegradable are these products? Have all of them really been tested or is 'biodegradable' just a marketing argument?

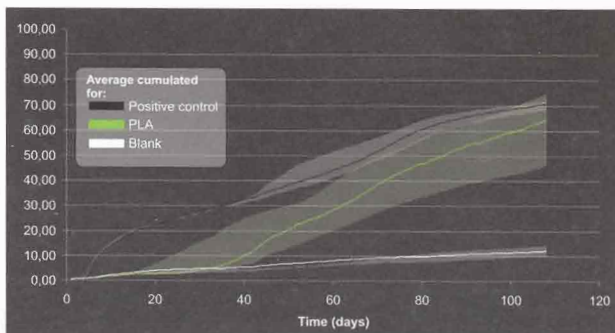
Wetlands Biosciences has developed a reproducible and cost effective test for the biodegradability of plastic materials. It is able to function with a high degree of autonomy, that limits labour costs and has a high degree of scientific accuracy through auto-calibration and continuous validation. The device can be used both by research centres and testing and certification laboratories.

Aerobic biodegradability of polymers can be examined by the method described in ISO standard 14855-1. In this procedure pieces of the test material of a defined size (2x2 cm) are mixed with mature municipal compost and incubated at 58°C for up to 6 months. The biodegradability of the material is assessed by comparing the amount of CO₂ produced by the mixture with the theoretical maximum evolution of CO₂ from the test material, corrected for the evolution from the compost itself and the organic and inorganic matter remaining.

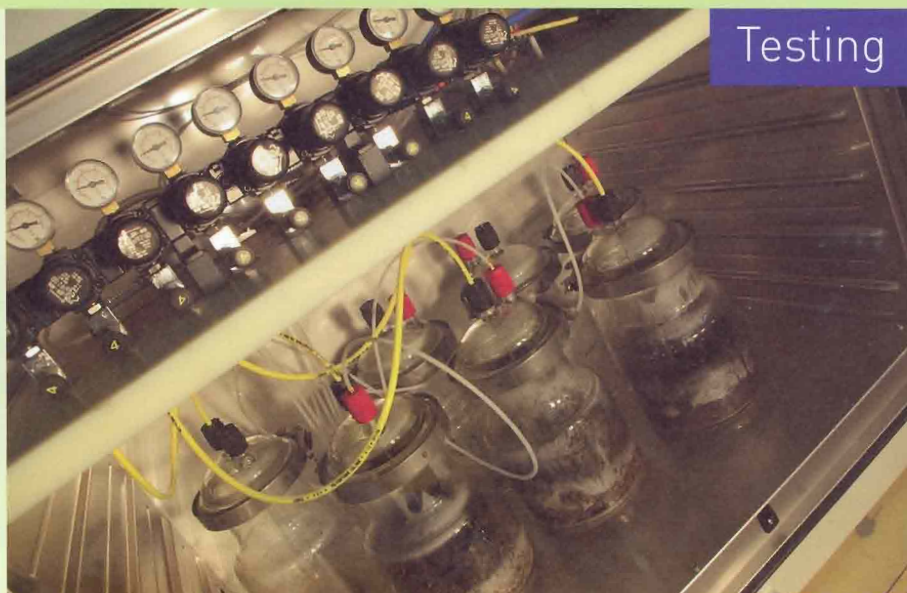
Method

A group of three 3-litre glass vessels with airtight lids and one inlet and outlet were used per experimental sample. The first group of three, the positive control group, contained 46 g of microfibrinous cellulose (Sigma-Aldrich) in 400 g of compost. The second group contained 46 g of polylactic acid (PLA), cut into pieces measuring 2x2 cm, in 400 g of compost. The last group, the blank sample, contained only 400 g of compost. At the start of the experiment all mixtures were humidified to the extent that manual squeezing of the compost produced a small amount of fluid. Vessels were aerated from the bottom by a diffuser and were made independent by virtue of the use of a separate pressure regulator for each individual vessel. Aeration flow was set individually for each vessel with a high

Average cumulated grammes of CO₂ by test



Article contributed by
Rob Onderwater,
Christian-Marie Bols and
Céline Dubois
Wetlands Biosciences SA,
Louvain-la-Neuve, Belgium



Bioreactors

precision manual valve. During the experiment the humidity of the compost was kept at around 50%, and the oxygen concentration was maintained above a minimum of 6% by regulating the flow of aeration. The compost was regularly mixed to ensure maximal homogeneity and minimize the formation of preferential routes for the aeration.

Results

For all vessels the initial aeration flow rate was set at 0.5 litres/min. The vessels in the positive control group with cellulose started to produce significantly more CO₂ than the blank sample group after 4 days. In order for the carbon dioxide concentration to be within range of the sensor, the flow rate was increased in the positive control group to 0.6 litres/min after 5 days, but was decreased again to 0.5 litres/min after 7 days. The vessels in the experimental group with PLA only started to produce significantly more carbon dioxide than the control group after 15, 28 and 32 days respectively. Initially carbon dioxide production in the PLA sample group was slightly inhibited as compared to the control group which resulted in a difference in cumulative production of carbon dioxide only being evident after 26, 36 and 42 days respectively. Carbon dioxide production in the blank sample group remained very stable throughout the experiment with a small difference between the vessels. In the blank sample group 1.75 +/- 0.35 g of CO₂ was produced in the first 10 days. In the positive control group 70.3 +/- 1.72 g of CO₂ was produced after 108 days (2.5% variability).

Observations

Positive control (Cellulose): At the beginning of the experiment an intense activity was observed, evidenced by the strong CO₂ increase. This phase is facilitated by the fact that the cellulose was added in the form of powder. After this phase, a strong, but stable activity remains before reaching a plateau phase due to the depletion of cellulose.

PLA: The PLA was in the form of film in 2x2 cm pieces and not in the form of powder or in crushed form. The advantage

of using the PLA in this way is that it was possible to observe its degradation visually. The launching phase is slower than in the positive control sample, this can be explained by the difficulty of the micro-organisms in degrading the PLA presented in this form. According to literature, the first phase of mineralization comes from the degradation of short chains which are immediately available to the micro-organisms. This was noted by the PLA pieces becoming firstly opaque and the subsequent formation of blisters on the material. The remaining fragments of highly crystalline PLA are much more resistant to degradation. Therefore, after a period of weak mineralization, which is relatively long, an increase in CO₂ evolution and progressive fragmentation of the material was noted.

Blank: The CO₂ release comes only from the internal activity of the already matured starting compost without addition of degradable material. A weak and stable release of carbon dioxide is thus observed over the experimental period.

NB: Each agitation and re-humidification of the bioreactors excited the activity of the micro-organisms temporarily, which resulted in a spike in CO₂ production.

Conclusions

The newly developed device was shown to function autonomously over an extended experimental period with limited intervention required (periodic agitation and humidification). Sensor integrities were maintained throughout the period and validation values remained OK. Values measured showed a high degree of accuracy, and little variability was observed among the vessels of the positive controls and among the vessels of the blanks. Variability among the vessels of the clearly highly biodegradable PLA was shown to be primarily due to the onset of mineralization.